ABSTRACT

DETERMINATION OF EROS PHYSICAL PARAMETERS FOR NEAR EARTH ASTEROID RENDEZVOUS ORBIT PHASE NAVIGATION

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Navigation of the orbit phase of the Near Earth Asteroid Rendezvous (NEAR) mission will require determination of certain physical parameters describing the size, shape, gravity field, attitude and inertial properties of Eros. Prior to launch, little was known about Eros except for its orbit which could be determined with high precision from ground based telescope observations. Radar bounce and light curve data provided a rough estimate of Eros shape and a fairly good estimate of the pole, prime meridian and spin rate. However, the determination of the NEAR spacecraft orbit requires a high precision model of Eros's physical parameters and the ground based data provides only marginal *a priori* information. Eros is the principal source of perturbations of the spacecraft's trajectory and the principal source of data for determining the orbit. The initial orbit determination strategy is therefore concerned with developing a precise model of Eros.

The original plan for Eros orbital operations was to execute a series of rendezvous burns beginning on December 20,1998 and insert into a close Eros orbit in January 1999. As a result of an unplanned termination of the rendezvous burn on December 20, 1998, the NEAR spacecraft continued on its high velocity approach tarjectory and passed within 3900 km of Eros on December 23, 1998. The planned rendezvous burn was delayed until January 3, 1999 which resulted in the spacecraft being placed on a trajectory that slowly returns to Eros with a subsequent delay of close Eros orbital operations until February 2001. The flyby of Eros provided a brief glimpse and allowed for a crude estimate of the pole, prime meridian and mass of Eros. More importantly for navigation, orbit determination software was executed in the landmark tracking mode to determine the spacecarft orbit and a preliminary shape and landmark data base has been obtained. The flyby also provided an oportunity to test orbit determination operational procedures that will be used in February of 2001.

The initial attitude and spin rate of Eros, as well as estimates of reference landmark locations, are obtained from images of the asteroid. These initial estimates are used as *a priori* values for a more precise refinement of these parameters by the orbit determination software which combines optical measurements with Doppler tracking data to obtain solutions for the required parameters. As the spacecraft is maneuvered closer to the asteroid, estimates of spacecraft state, asteroid attitude, solar pressure, landmark locations and Eros physical parameters including mass, moments of inertia and gravity harmonics are determined with increasing precision.

The determination of the elements of the inertia tensor of the asteroid is critical to spacecraft orbit determination and prediction of the asteroid attitude. The moments of inertia about the principal axes are also of scientific interest since they provide some insight into the internal mass distribution. Determination of the principal axes moments of inertia will depend on observing free precession in the asteroid's attitude dynamics.

Gravity harmonics are in themselves of interest to science. When compared with the asteroid shape, some insight may be obtained into Eros' internal structure. The location of the center of

mass derived from the first degree harmonic coefficients give a direct indication of overall mass distribution. The second degree harmonic coefficients relate to the radial distribution of mass. Higher degree harmonics may be compared with surface features to gain additional insight into mass distribution.

In this paper, estimates of Eros physical parameters obtained from the December 23,1998 flyby will be presented. This new knowledge will be applied to simplification of Eros orbital operations in Februray of 2001. The resulting revision to the orbit determination strategy will also be discussed.

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